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The Use of Biotechnology for the Improvement of Cassava, Yams and Plantain in Africa

CONSTRAINTS ON CASSAVA AND YAM RESEARCH AND PRODUCTION IN AFRICA

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The major tropical root crops—cassava (*Manihot esculenta* Crantz) and yams (*Dioscorea* spp.)—are widely grown and are mostly used as subsistence staples in many parts of the tropics and subtropics in Africa. They are the major source of energy for well over 200 million people on the continent. The leaves of cassava are often used as a vegetable providing protein, vitamins and minerals.

A. Cassava research and production constraints

1. *Diseases and pests*

(a) *Cassava mosaic virus*

Cassava mosaic virus (CMV), which is widespread and is an economically important disease, can cause yield losses of up to 95 percent. Losses of 80 percent from CMV are common while losses of 20 percent are normal in many parts of West Africa. The causal agent of CMV is a gemini virus. The CMV incidence depends on the population and activity of *Bemisia tabaci* which transmits the disease. IITA has identified sources of resistance to CMV and this resistance has been successfully incorporated into high yielding cultivars of acceptable quality.

The mechanism of resistance to CMV is not yet understood. Whether resistance to CMV is due to physical barriers or to antiviral factors needs to be investigated. Besides, the pathogenic variation of CMV needs to be studied. As for the international distribution of virus-free clonal material, virus indexing method should be improved.

(b) *Cassava bacterial blight*

Cassava bacterial blight disease (CBB) is one of the most devas.ating plant bacterial diseases. CBB occurs in many countries in South America and in Africa. The causal agent of this disease is *Xanthomonas campestris* pv. *manihotis*. Characteristic symptoms of CBB are angular, watersoaked leaf spots, as well as blight, wilting, die-back, gum exudation and stem and root vascular necrosis. On the other hand, *X. campestris* pv. *cassavae* induces circular leaf spots surrounded by a yellow halo. It also causes radial necrosis of veins followed by defoliation. Local cultivars are susceptible to CBB which often causes complete crop failure under heavy infection. Sources of resistance to CBB were identified and resistant clones have been developed.

(c) *Other diseases*

Other diseases such as cassava anthracnose and cassava root rot disease are also important.

(d) *Cassava green spider mite*

Cassava green mites (CGM) can reduce tuber yield by up to 40 percent, especially in the late planted crop. Since it was first reported in Uganda in 1972, CGM has become a serious pest throughout the major cassava growing areas in Africa. CGM is a dry season pest and it is spread by infested planting material and by wind, but it is not clear how the mites are carried on the planting material. However, the most important method by which CGM is dispersed is by wind. In the morning, adult mites lower themselves from the leaves on silken thread so that even low wind currents can carry them over long distances. This may be why the mite spreads so fast at 300 km a year.

(e) *Cassava mealybug*

Cassava mealybug (CM) can reduce tuber yield by up to 54 percent in early planted cassava and up to 84 percent in the late planted crop while it causes 100 percent loss for the leaf. CM was first reported in Zaire in 1973 and in 1977 it was described as *Phenacoccus manihoti* from specimens collected in Congo and Zaire. Since it was first discovered, CM spread rapidly so that by 1980 it had covered almost all the major cassava growing countries on the west coast of Africa.

IITA has taken two approaches to tackle these two pests, CGM and CM, by host plant resistance breeding and biological control. Resistance to CGM and CM is associated with pubescence. The average CGM scores of pubescent types are lower than those of non-pubescent types. Varieties that have some level of resistance to CGM and CM have been identified. Natural enemies of CM were found to be efficient in controlling CM.

2. *Nematodes*

Nematodes are becoming more and more important as human population increases. This is because fallow periods are becoming shorter and food crops are being planted more frequently. While nematodes can be controlled through cultural, physical, chemical and biological methods, developing resistant cultivars increases and stabilises yields. At the same time, these improved cultivars are available to the farmer at no extra cost to him.

The most important nematodes of cassava are the root knot nematodes, the root-lesion nematodes, the reniform nematodes, the spiral nematodes and the false spiral nematodes. Studies at IITA show that cassava is an excellent host for a number of nematode species.

3. *Quality characteristics*

(a) *Low in protein*

The protein content of cassava is low. This is often said to be the cause of malnutrition in high consumption areas.

(b) *Cyanide in the leaves and tubers*

Cassava contains hydrogen cyanide in tubers and leaves in the form of cyanogenic glucosides which release HCN on hydrolysis when tissues are destroyed. No acyanogenic cassava variety has been reported, but the level of HCN varies with variety. It is necessary to eliminate this cyanide to improve palatability through processing with different products.

(c) *Poor visco-elastic properties*

Cassava flour has been tested as a substitute for wheat flour in bread making in order to reduce the cost of the bread. Because of the poor visco elastic properties of cassava flour, the most suitable variety can only replace 20 percent of the wheat flour.

4. *Processing*

The cyanide in cassava makes it necessary to process the tubers. This is labor-intensive and at the same time peeling and grating cause high losses. The poor storability of cassava tubers after harvesting is also a problem.

5. *Poor genetic studies*

Very limited genetic studies have so far being carried out on this crop.

6. *Dry matter vs. fresh yield*

It has been shown that high fresh tuber yield is negatively correlated with dry matter yield.

7. *Symbiotic organisms*

Cassava can be grown under marginal soil conditions. Mycorrhizae have been reported to be associated with cassava and to contribute to the performance of cassava under poor soil. The role of mycorrhizal association is not clear. Other symbiotic or free living organisms might have these associations.

8. *Shy flowering*

Shy flowering in some cassava varieties, particularly those that have desirable characteristics, has prevented the utilization of such genetic materials for breeding.

B. Yam research and production constraints

The most economically important yam species grown in Africa are white yam (*Dioscorea rotundata*), yellow yam (*D. cayenensis*), trifoliate yam (*D. dumetorum*) and water yam (*D. alata*). In Africa, white yam is grown on the largest scale and at the same time is the most preferred followed by water yam and yellow yam. Africa produces 96 percent of world yam production.

Yam production requires high inputs and is labor- intensive. The crop is difficult to grow because seed yams are expensive and often unavailable, seedbed preparation is laborious and tedious, staking is necessary and yet staking material is expensive and often not available, weeding is required for 4 to 5 months and harvesting needs special care. Browning of the tuber, low multiplication rate and sprouting after dormancy period are among the constraints. Other research and production constraints are:

1. *Diseases and pests*

(a) *Yam mosaic virus*

The causal agent for this disease is a potyvirus transmitted by aphids. The disease symptoms vary because of host/pathogen interaction. Typically, mosaic patterns and chlorosis occur. Under severe attack the plants appear stunted. Other symptoms such as leaf distortion, shoestring, vein clearing, green vein banding, mottling and stunting are also observed.

(b) *Water yam chlorosis*

The causal agent of this disease is not clear; possibly a potyvirus is involved. A wide range of symptoms can be observed during all stages of plant development. Typical symptoms include chlorosis, flecking, vein clearing, puckering, necrosis, and scorching. This disease needs to be studied.

(c) *Yam storage rot*

This problem arises mainly from the wounding and bruising during harvesting or transporting of the tubers. Pathogens involved are a wide range of fungi and bacteria.

(d) *Yam tuber beetles*

Yam tuber beetles make feeding holes of varying shapes on yam tuber, resulting in low tuber marketability. Yam setts are attacked after planting and the vegetative development of the plants can be limited.

2. *Nematodes*

The nematodes attacking yams are mainly the yam lesion and rootknot nematodes. The yam nematode is found both in roots and tubers and in the soil. Yam tubers attacked by lesion nematodes show tissue discoloration, dry rot and deep cracks in the surface tissue. The rootknot nematode symptoms appear as light to heavy galling of the tuber and knobby or bumpy tuber surface. They reduce the market value of the tubers. *D. dumetorum* shows high resistance to the nematode

3. *Flowering*

Shy flowering and the non-synchronization of male and female flowers are bottlenecks in yam improvement. So far only male flowering *D. cayenensis* are observed. Can we introduce the desirable characters from *D, cayenensis* to *D. rotundata*? The genetics of this crop needs to be well studied.

4. *Non-pathogenic bacteria*

Non-pathogenic bacteria were found in the leaves of yam. There are varietal differences in the amount of bacteria accommodated in the leaf. The role of such bacteria on the host plant is not clear and further investigations are required.

5. *Germplasm preservation*

Preservation of yam germplasm under field conditions is very difficult. The labor involvement is tremendous. The most problematic is the loss of germplasm due to nematode attack, rot in the field and during storage and other diseases.